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Project Babylon: The Iraqi Supergun (U)

A Research Paper

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Contents

Project Babylon: The Iraqi Supergun (U)

Summary

Information available as of 9 October 1991 was used in this report.

From 1988 until 1990, Iraq was involved in an unusual weapons development program it called Project Babylon. This project included the development, manufacture, and construction of several large-caliber guns, including a 1,000-millimeter-diameter supergun. In addition, Project Babylon encompassed the development of projectiles for these guns that included conventional and rocket projectiles capable of being fired to great distances—on the order of a 1,000 kilometers for the gun-launched rockets. This project was coordinated for Iraq by the Space Research Corporation (SRC), which was also heavily involved in the development of the guns and projectiles. Israeli intelligence staff believe these guns were intended for the bombardment of unspecified military and economic targets. (S NF—NC)

By early 1990, Iraq had successfully built and fired a 350-mm-diameter scaled version of the 1,000-mm supergun. Also, by this time, many components for the 1,000-mm supergun and two other 350-mm guns—whose immense size required out-of-country manufacture—had been delivered to Iraq. However, construction of the supergun and the two other 350-mm guns had not begun. (S NF)

In March 1990, the murder of Gerald Bull, the project leader, was the first link in a chain of events that drastically slowed the progress of Project Babylon and ultimately led to its termination. Worldwide disclosure in April 1990 of the project occurred when UK customs seized the last eight sections that were to make up the 1,000-mm gun barrel. Other components, including several critical components like gun-barrel sections and breeches, were subsequently seized by various countries. Without these critical components, the supergun could not have been completed by Iraq. We are unable to find any evidence that Iraq obtained out-of-country aid for the project after its disclosure. (S NF)

In July 1991, in the aftermath of the Persian Gulf war, Iraq acknowledged "a long-range gun program," despite its initial denials that there was such a program. The Iraqis also admitted to the existence of the 350-mm diameter test gun and to its location, and they provided information on status of the components that were to make up the 1,000-mm supergun and two other 350-mm guns. Examination of the 350-mm test-gun site, the supergun components, and other gun components by a United Nations inspection team revealed that Project Babylon has, in fact, been terminated. In October 1991, procedures were implemented by the United Nations for the destruction of the Project Babylon components, including the 350-mm test gun. (U)

Gerald Bull

At age 22, Gerald Bull was one of Canada's youngest citizens to earn a doctorate in aerodynamics (see figure 1). He became known for creative solutions—using a gun instead of a wind tunnel to conduct inexpensive hypervelocity aerodynamic studies—and for his impatience with what he termed "amateur scientists" and "bureaucratic redtape." At age 32, he led the extremely ambitious joint US-Canadian High-Altitude Research Project (HARP), developing state of the art for gun-launched projectiles and rockets. (U)

Soon after the end of the HARP program in 1967, Bull founded the Space Research Corporation (SRC) and built a test facility near Highwater, Quebec. He purchased the HARP guns and equipment at scrap-value prices from the US and Canadian Governments—apparently considering the idea of reviving his dream of building large-caliber guns. Through a special act of the US Congress in 1972, Bull was granted US citizenship and a security clearance and was awarded up to $9 million in defense contracts. After the establishment of an SRC subsidiary in Belgium, Bull developed the GC-45 gun—considered to be one of the best artillery guns in the world—and advanced projectiles with almost twice the range of guns in the US arsenal. (U)

Bull was unsuccessful in convincing the US Army to purchase his GC-45 gun and ammunition. Therefore, he decided to sell the GC-45 to the South Africans with what he considered to be approval from the US Office of Munitions Control. Later, he was charged with violating the arms embargo to South Africa and, after pleading guilty in 1980, was sentenced to 6 months in prison. Upon release from prison, he vowed never to return to North America and moved his operations to Brussels. (U)

Bull continued to sell his GC-45-mm gun, ammunition, and technology worldwide; he sold at least 200 systems to Iraq in the mid-1980s. According to Mossad Saddam Husayn was extremely impressed with these artillery guns. Further, it is possible that Bull personally persuaded Saddam Husayn to fund his dream: the building of a 1,000-millimeter supergun that could launch payloads into space as well as deliver warheads to great distances. In 1988, Iraq made Bull's SRC the managing authority for the supergun project, known as Project Babylon. (S NF)

Project Babylon:
The Iraqi Supergun (U)

Background: Why a Supergun?

Project Babylon was Iraq's program to construct a supergun. The brainchild of Gerald Bull, a naturalized US citizen, the program was started by Space Research Corporation (SRC) in 1988. Bull became obsessed for almost 10 years with building the world's largest gun that would be capable of launching payloads into space. We believe that Bull tired of his obsession as much as any technical or military consideration was instrumental in convincing Iraq to initiate Project Babylon (see inset and right figure 1.) (U)

Figure 1. Gerald Bull designer of the supergun inspects one of his large-caliber guns in 1965

Few hard facts have been obtained about Iraq's requirements for Project Babylon. Speculation abounds on why Iraq funded a project to build a 1,000-millimeter supergun, several 350-mm diameter guns, and their projectiles. Arguments within the Intelligence Community have ranged from the belief that the gun systems possess no benefits over comparable missiles systems to the belief that the gun systems are better because gun-launched rocket projectiles would be difficult to intercept as compared with missiles launched by Iraq's Soviet-built MAZ-543 Bull considered a large-caliber gun firing rocket projectiles to be an efficient and reusable "first stage" capable of delivering moderately sized projectiles on the order of 100 kilograms (kg). In addition, Bull boasted that a 1,000-mm gun system could be developed for far less cost than a comparable (in terms of payload) missile system. Our analysis generally supports Bull's conclusions. (NF-NCON)

The HARP Program: Forerunner to the Supergun

Project Babylon can be traced back to the 1960s joint US-Canadian High-Altitude Research Project (HARP), which used large-caliber guns to conduct upper-atmospheric research experiments. The HARP program succeeded in setting the world altitude record of 180 kilometers (km) for a gun-fired projectile Further, the HARP program extended gun-launch technology, demonstrating that firing rockets from guns was feasible and that guns were theoretically capable of launching payloads to low Earth orbit or to targets thousands of kilometers downrange. The HARP program was ended in 1967 as missile technologies matured. (U)

The HARP program consisted of several guns, the largest being a modified US Navy 16-inch (406-mm) gun (see figure 2). This gun fired both subcaliber projectiles [1] and single-stage, solid rockets. One version of this gun- -known as the Highwater gun because of its location in Highwater, Quebec –consisted of three 16-inch gun barrels bolted together. This gun was limited to horizontal firings over a flight range of 3 to 5 km (see figure 3). Test firings included projectile-sabot structural-proof tests and development testing of large, full-bore rockets with a total mass of about 1,000 kg. (U)

The state of the art for launching rockets from guns was reached during the HARP program. Specifically, difficulties associated with rocket-component and rocket-motor survival at high-launch accelerations, experienced while the rocket travels down the gun barrel, were solved. These solutions included the development of hardened components and a novel approach for supporting center-burning rocket motors. The program succeeded in firing a 180-mm fiberglass-wrapped rocket from a horizontally mounted gun (see figure 4). These tests proved that rockets could be fired from guns and, according to analysis by HARP scientists, to altitudes of over 500 km, depending on payload and rocket exit velocity. By the end of the HARP program, this development culminated in the construction of a 16-inch, two-stage solid rocket, known as Martlet 2G-1, which was fired from the gun in Highwater, Quebec, again in a horizontal position (see figure 5). HARP scientists began to design a different version of this rocket, one with three stages, which they believed would be capable of placing a small (size unspecified) payload into Earth orbit. (U)

The ultimate rocket projectile envisioned during the HARP program was a multistaged, full-bore rocket designated Martlet 4 (see figure 6). This rocket was designed to carry payloads of up to 200 kg to low

Figure 2 The 16-inch HARP gun firing at the Barbados Test Range (U)

Earth orbit. Work on this rocket projectile never progressed beyond the drawing board during HARP's duration. (U)

Project Babylon: Attempt To Build a Supergun

As Mossad shared intelligence data with us, Project Babylon loosely consisted of two phases and several subprograms. Some of these data refer to Phase 1 as

[1] A subcaliber projectile has a diameter smaller than the diameter of the gun barrel A sabot is used to position the smaller diameter projectile within the gun barrel Subcaliber projectiles are used primarily because of their lower mass as compared with full-diameter projectiles. Consequently, subcaliber projectiles can be fired at higher velocities than would be capable with full-diameter, heavier projectiles A disadvantage of subcaliber projectiles is that they have a smaller (sometimes much smaller) payload capacity (U)

by joining three 16-inch naval gun barrels together It was used to service gun-launched rocket projectiles

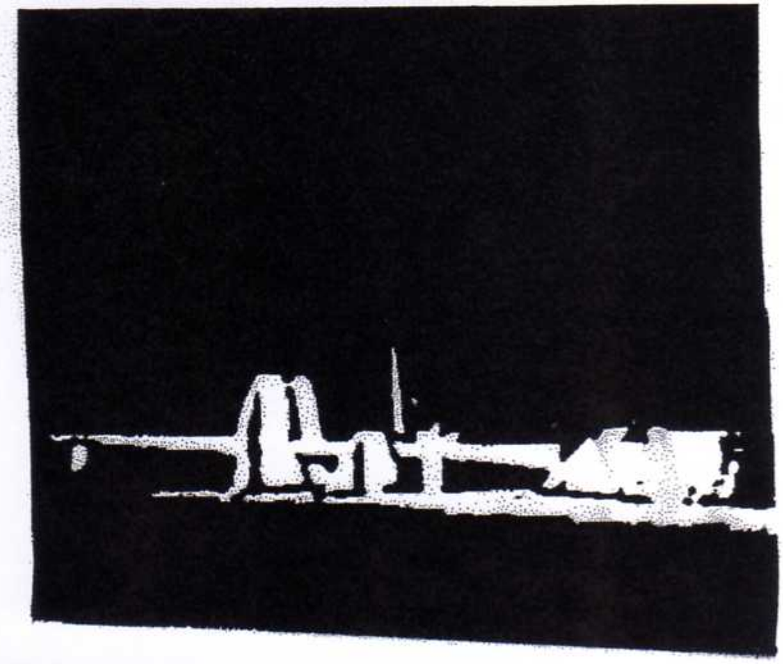

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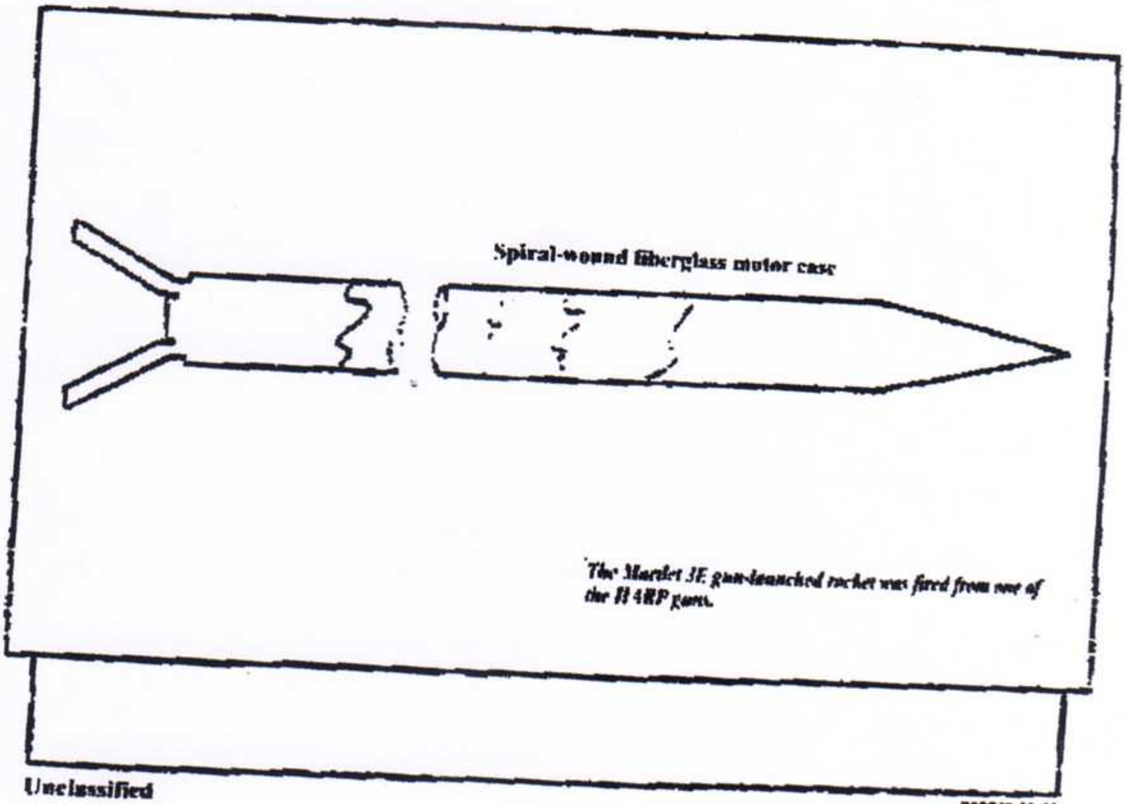
Figure 4
Martlet 3E Gun-Launched Rocket



The Martlet 3E gun-launched rocket was fired from one of the HARP guns.

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Figure 5
Martlet 2G-1 Gun-Launched Rocket

The Martlet 2G-1 was fired from the 16-inch gun in Highwater, Quebec.

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the design and construction of two large, 1,000-mm superguns and to Phase II as the design and construction of two smaller elevating and traversing 350-mm guns (see figure 7). US Navy intelligence considered that Phase II was the development of gun-launched rockets (GLRs) for both the 1,000-mm and 350-mm guns. We differentiate between the various phases and subprograms as follows. (S NF NC OC)

Phase I
Phase I involved a 1,000-mm-diameter supergun designated S-1000 (see figure 8). This gun was to have a barrel length of 150 meters and was to have been emplaced in a fixed position on a mountainside at about a 45-degree elevation. This gun would be able to fire on targets only along its fixed gun-target line.

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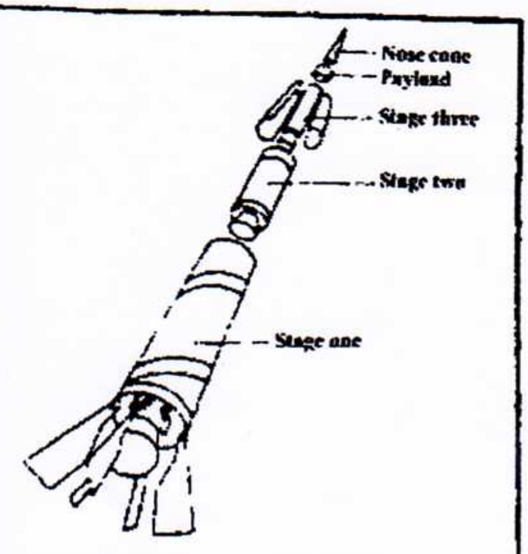
Figure 6
Martlet 4 Gun-Launched Rocket



The Martlet 4 was to be a multistage, full-bore, gun-launched rocket. The intent of this rocket, fired from the 16-inch HARP gun, was to launch payloads into low Earth orbit.

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Apart from other sources, Husayn Hassan Kamel has also confirmed to us that no construction of the 1,000-mm supergun had ever occurred. (S NFNC OC)

Supporting Phase I was a scaled version of the S-1000 supergun, known as the S-350 L150, with a 350-mm-diameter barrel (see the section, "The Only Gun To Fire: The S-350 L150"). This smaller scale gun was successfully test-fired, in a horizontal position, using test slugs and subcaliber projectiles. It was later moved to an inclined site for further testing to more accurately replicate the emplacement of the larger supergun. (S NF NC OC)

Also supporting Phase I was another 1,000-mm-diameter test gun that was to have been mounted horizontally for test firings. This gun was to be the prototype whose data would have been combined with that of the 350-mm test gun for incorporation into the finalized design of the operational 1,000-mm supergun. From satellite images, we know that some preliminary work on the support structure for the 1,000-mm horizontal gun had been done by early 1990. Even though the fabrication of some 1,000-mm horizontal-gun parts had occurred, construction of the gun itself had never been started. (S NF)

Phase II
We believe that Phase II of Project Babylon involved two 350-mm-diameter guns, designated S-350 F.T. capable of elevating and traversing (see figure 9). These guns would provide a more flexible system than the fixed supergun for targeting—the capability to fire on targets at various azimuths. SRC gun designers indicated, as revealed in documentary data, that the payload capacity of the subcaliber projectiles would be very small—about 15 to 20 kg. The designers began planning GLRs that would provide these 350-mm guns with the capability to deliver a 100-kg payload to a range of about 1,000 km. We believe, therefore, that GLRs were intended as the primary projectile for these smaller guns. (S NF)

Other Guns
Separate from Phase I or II were guns of 500-mm and 600-mm caliber proposed by the SRC and at least considered by Iraq. Initially, a 500-mm gun was examined to address the issue of the small-payload capacity of the S-350 guns, particularly with their subcaliber projectiles. This 500-mm gun, like the S-1000, would be in a fixed position and fire both GLRs and subcaliber projectiles. No construction or component procurement for this gun occurred. (S NF NC)

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Figure 7
Guns of Project Babylon

Phase I: **Goal:**
- 1,000-mm operational supergun

Status:
- Some components delivered
- No construction of 1,000-mm operational supergun
- Some components seized
- 350-mm gun constructed and test-fired

S-1000

Support:
- Scaled 350-mm test gun initially in horizontal position
- Later disassembled and reassembled on side of mountain
- Full-scale 1,000-mm test gun was to be horizontally mounted for test firings

S-350 L150

Phase II: **Goal:**
- Two 350-mm operational guns capable of elevating and traversing

Status:
- Components procured
- No construction
- Some components seized

S-350 ET

Other guns:
- 600-mm gun
- 500-mm gun

Status:
- Only on drawing board
- No construction
- No components procured

S-600

These guns comprised Project Babylon, whose goal was to build a 1,000-mm supergun and two 350-mm elevating and traversing guns. Of the guns considered, only a 350-mm test gun was ever built and fired.

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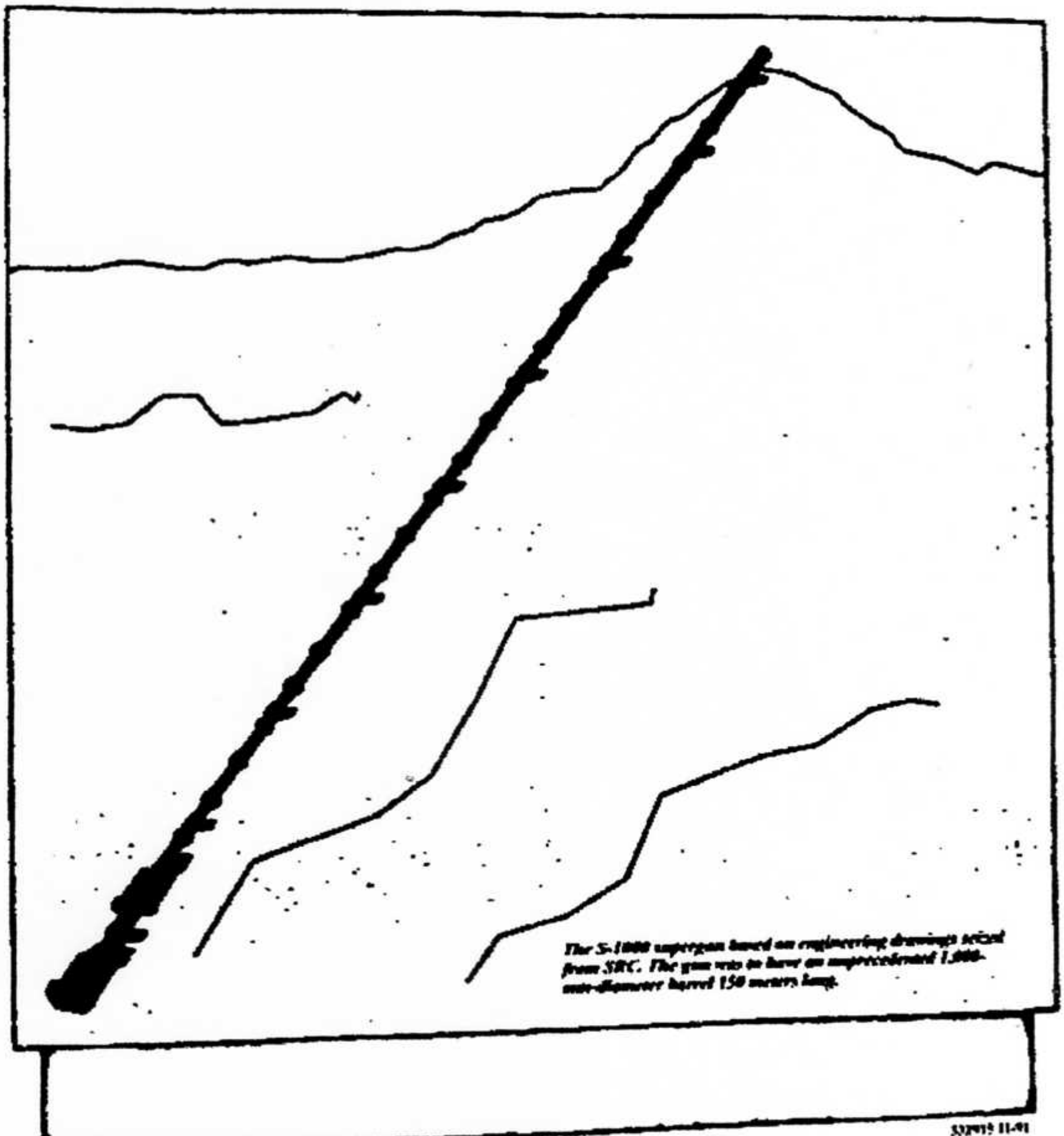
Figure 8
The S-1000 Supergun



The S-1000 supergun based on engineering drawings seized from SRC. The gun was to have an unprecedented 1,000-mm-diameter barrel 150 meters long.

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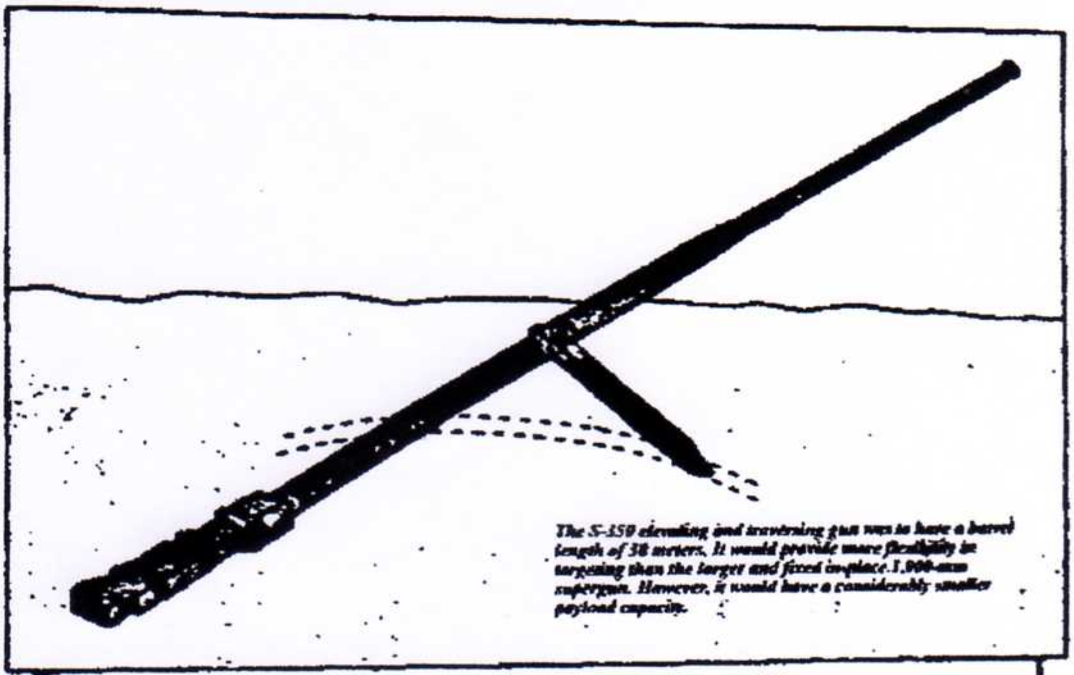
Figure 9
S-350 Elevating and Traversing Gun



The S-350 elevating and traversing gun was to have a barrel length of 38 meters. It would provide more flexibility in targeting than the larger and fixed in-place 1,000-mm supergun. However, it would have a considerably smaller payload capacity.

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Unspecified problems during the development of the 1,000-mm supergun were implied by SRC endorsement of another large-caliber gun, as revealed in documentary data. A plan for a 600-mm gun system was in the proposal stage in early 1990 (see figure 10). This gun was to have provided the capability to launch larger payloads than the 350-mm guns, because of its larger size, and was to have provided more targeting flexibility than the fixed 1,000-mm supergun, because it could elevate and traverse. We believe that this 600-mm gun represented a "lower-tech solution" as compared with the larger supergun and, consequently, may have been easier to develop. While US Navy staff deem that this 600-mm gun was designed to fire subcaliber and (simpler) rocket-assisted projectiles (not GLRs) similar to those fired from conventional artillery guns. (S NF)

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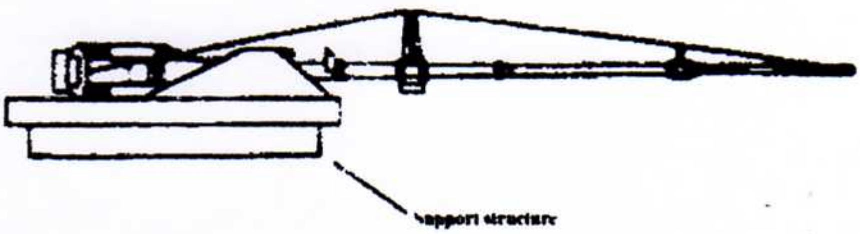
Figure 10

The 600-mm Elevating and Traversing Gun



The 600-mm elevating and traversing gun was to have a barrel length of 60 meters. Apparently SRC was having difficulties with the larger 1,000-mm supergun and was recommending this gun to Iraq.

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Projectiles

Two projectile types were considered for Project Babylon: subcaliber projectiles and GLRs. These projectile types, like most of Project Babylon, borrowed heavily from the HARP program. A variety of projectiles had been identified and were in various stages of development by early 1990 (see table 1). (S NF)

Seized SRC documents bear out that these cylindrical test slugs were constructed for the proof testing of the S-350 L150 test-gun breech and barrel. These test slugs, though aerodynamically unstable, were intended to duplicate the actual projectile's mass (see figure 11). The test slugs allowed the proper internal gun

Table 1
Project Babylon Projectiles

Gun (milli-meters)	**Remarks**
S-1000 (1,000-mm)	The supergun was intended to fire gun-launched rockets.
S-350 L150 (350-mm)	This scaled down version of the S-1000 supergun successfully fired test slugs and subcaliber projectiles.
S-350 ET (350-mm)	Payload capacity of the sub-caliber projectiles would be very small, about 15-20 kg. We believe GLRs were intended to be used as the primary projectile for these smaller guns with a capacity of 1,000 kg.
S-600 (600-mm)	Only on the drawing board this gun was planned to fire both GLRs and subcaliber projectiles

pressures to be achieved and provided interior ballistics calibration for the computer codes used in the design of all the guns. In addition, these test slugs allowed SRC designers to determine the proper propellant amount and configuration to achieve optimum performance from the 350-mm gun (see appendix A, "Interior Ballistics"). The final propellant geometry, as determined from the 350-mm gun test firings, would be scaled up for use in the 1,000-mm supergun. (S NF)

Several test projectiles, designated S32, were constructed and fired from the horizontal S-350 L150 test gun, according to available SRC documents (see figure 12). These projectiles were to be fired downrange for the first time during the inclined S-350 L150 test program. The primary purpose of these projectiles, confirmed by seized SRC documents, was to test the overall configuration of the subcaliber projectiles and provide a basis for extending the design to the S-1000 supergun. Consequently, we do not believe that these projectiles could have been easily weaponized. (S NF NC)

We assess that no completed gun-launched rockets exist for any of the Project Babylon guns. Israeli Intelligence state that the drawings they seized from the site, shows that their design was well advanced by early 1990 (see figure 13). However, much work and testing were required before they could become operational. Even though the Project Babylon GLRs were based on the HARP's designs, SRC gun designers conceded that GLR complexity required extensive out-of-country assistance (S NF NC)

Guidance and Control
Gerald Bull's papers show that "no real productive work" had been done on a projectile guidance and control (G&C) system, mainly for the GLRs, through March 1990. Documentary data further reveal that this was an area where SCR designers were least competent. Apparently, SRC personnel with necessary G&C system experience and expertise were not working directly on Project Babylon. Only a general study of G&C schemes, with a superficial analysis of a technique for the Project Babylon projectiles, was presented to Iraq by the SRC. Because so little work was done in this area, Iraq was withholding funding from the SRC until progress was demonstrated. (S NF)

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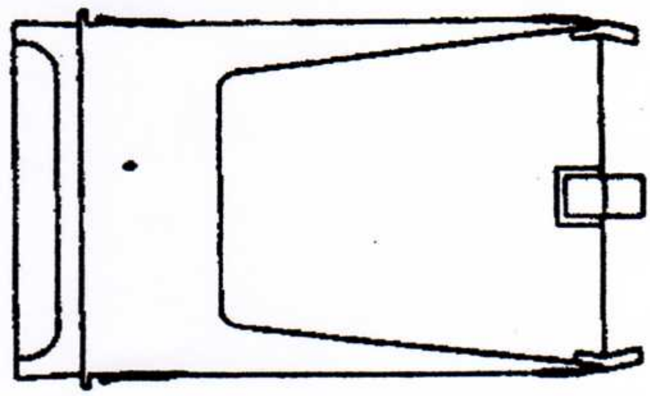
Figure 11
Test Slug Fired From the S-350 Test Gun



The test slug used during pressure proof testing of the S-350 L150 gun. Several of these test slugs were fired from the horizontally mounted gun and were planned for the inclined-gun testing as well.

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Documentary data reveal that a relatively simple G&C scheme was investigated. A ground-based radar would track the projectile after firing, and a ground-based computer system would combine this tracking data with exit velocity and meteorological data to determine what corrections were required to hit the desired target. Correction commands would be transmitted to the projectile by a ground-based controller, adjusting control surfaces (fins) located on the projectile body, to change its course. This type of G&C system requires that all necessary maneuvering be accomplished while the projectile is in the atmosphere immediately after firing, a period of about 30 seconds, according to SRC calculations. (S NF NC)

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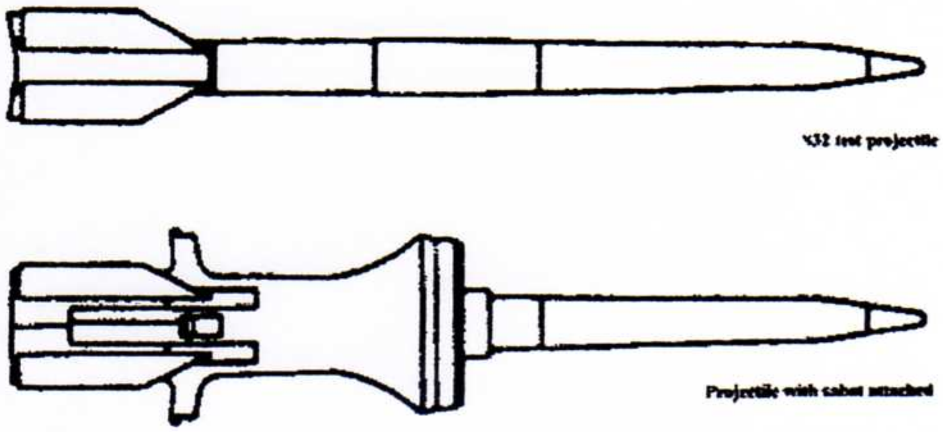
Figure 12
S32 Subcaliber Projectile for the S-350 Test Gun



The experimental subcaliber projectile designated S32 is the only known projectile to have been fired by the Iraqis during Project Babylon. The lower drawing shows the projectile with its sabot attached.

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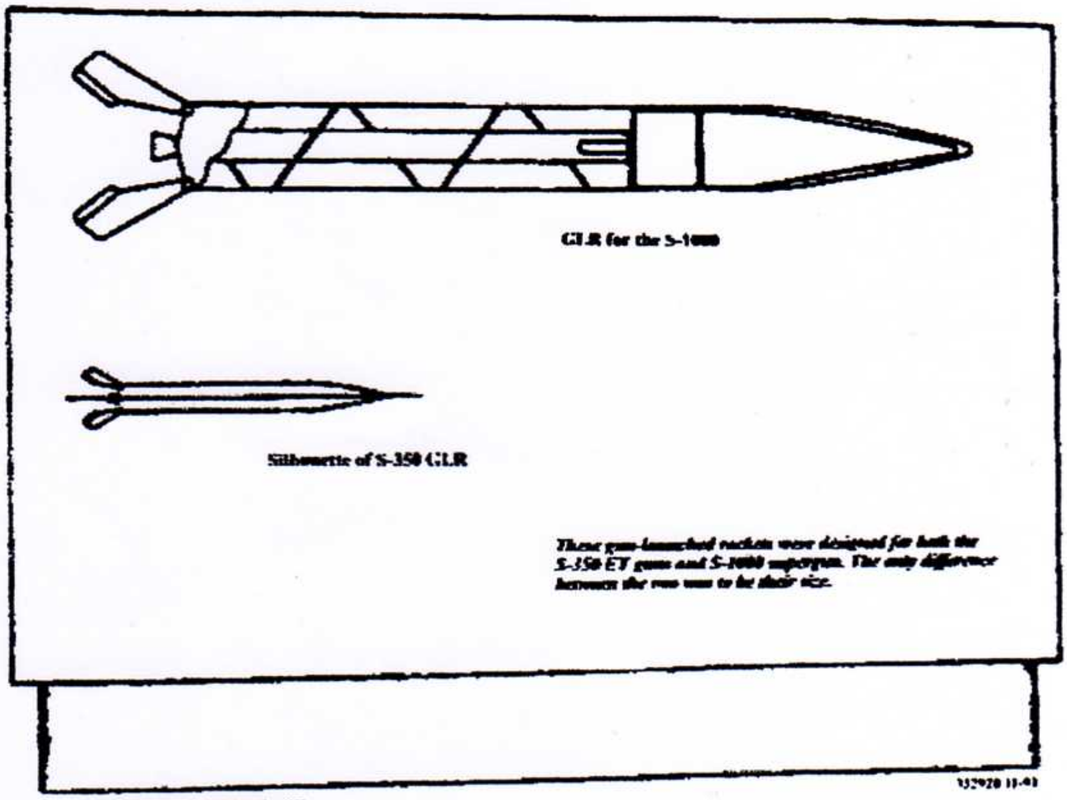
International Participation Vital to the Project

Participation of companies outside Iraq was essential for Project Babylon. This participation supplemented lacking in-country manufacturing capability and helped to maintain the fast-paced schedule that had been established for the project. The sheer size of the supergun and its components required the support of a variety of companies from all over the world, including the United Kingdom, Switzerland, Spain, Italy, and Belgium (see table 2). These companies manufactured components, including barrel sections, recoil mechanisms, propellant, elevating and traversing

Figure 13
Gun-Launched Rockets



These gun-launched rockets were designed for both the S-350 ET guns and S-1000 supergun. The only difference between the two was to be their size.

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items, and structural pieces. No one company manufactured all the components necessary to construct a gun, and, apparently, some companies were not even aware that they were building components intended for a gun system. (S NF)

Most of the components for all the Project Babylon guns were delivered to Iraq by early 1990, with the exception of some critical components. In April, however, when UK Customs seized the last eight sections that make up the 1,000-mm gun barrel, public disclosure prevented the delivery of any more items. Before then, some 44 other 1,000-mm-barrel tubes had already been delivered to Iraq and had been identified

Table 2
Iraqi Supergun out-of-country sources of components

Country	Description
United Kingdom	Tubes for barrel sections for test gun. Components for elevating and traversing guns and test gun. Gun barrel flange seals.
Spain	Elevating and traversing items and structural support pieces.
Switzerland	Breech and recoil components.
Belgium	Recoil components.
Netherlands	Propellants.
Italy	Diverse components including barrel and yoke housing assembly and breech for S-1000 gun.

at the industrial park at Iskandiaria (see figure 14). In addition, the barrels for the S-350 ET guns had also been delivered to Iskandiaria. The seized components were never delivered, and complete construction of the 1,000-mm supergun and 350-mm elevating and traversing guns could not have taken place without them. (S NF NC W N)

The companies primarily involved with the construction of the supergun barrels were in the United Kingdom. Sheffield Forgemasters contracted to build fifty-two 1,000-mm-diameter tubes that would comprise the barrel for the 1,000-mm horizontal test gun and the operational supergun. Walter Somers was commissioned to build the barrels, as well as other components, for the two smaller 350-mm elevating and traversing guns and the 350-mm test gun that was fired. Another UK firm, Astra, supplied flange seals for the gun barrels of both size guns. (S NFNC)

Other components for the Project Babylon guns were constructed by various companies from several countries. Two Spanish firms, Rio Tinto and Unceta, were involved in the construction of elevating and traversing items and structural support pieces. Oerlikon of Switzerland built at least one breech for the S-350 ET gun and, in addition to Gechem of Belgium, built recoil components for guns of both sizes. Agusta of Italy, supplied a variety of components, including a barrel and yoke housing and possibly a breech for the S-1000 gun. Many of these components were delivered to Iraq by early 1990. (S NFNC)

The Only Gun to Fire: The S-350 L150

Only one Project Babylon gun was completed and test-fired. The construction of a 350-mm-diameter test gun was completed sometime near the end of 1989, and some firings of the gun in a horizontal position were conducted. This 350-mm gun test program would allow SRC designers to update the 20-year-old HARP program data base with information about guns built with modern materials and about newer construction techniques. We believe that these tests were probably not completed. (S NF)

Initially, this test gun was horizontally mounted on railcars and possibly fired as many as 15 test projectiles (see figure 15). Railcars were used because no recoil mechanism had yet been built. The firing of the gun caused the railcars to move backward several meters. By March, this gun was dismantled and reassembled at another test location in the Hamrin Mountains at a 45-degree inclination. (S NF NCOC)

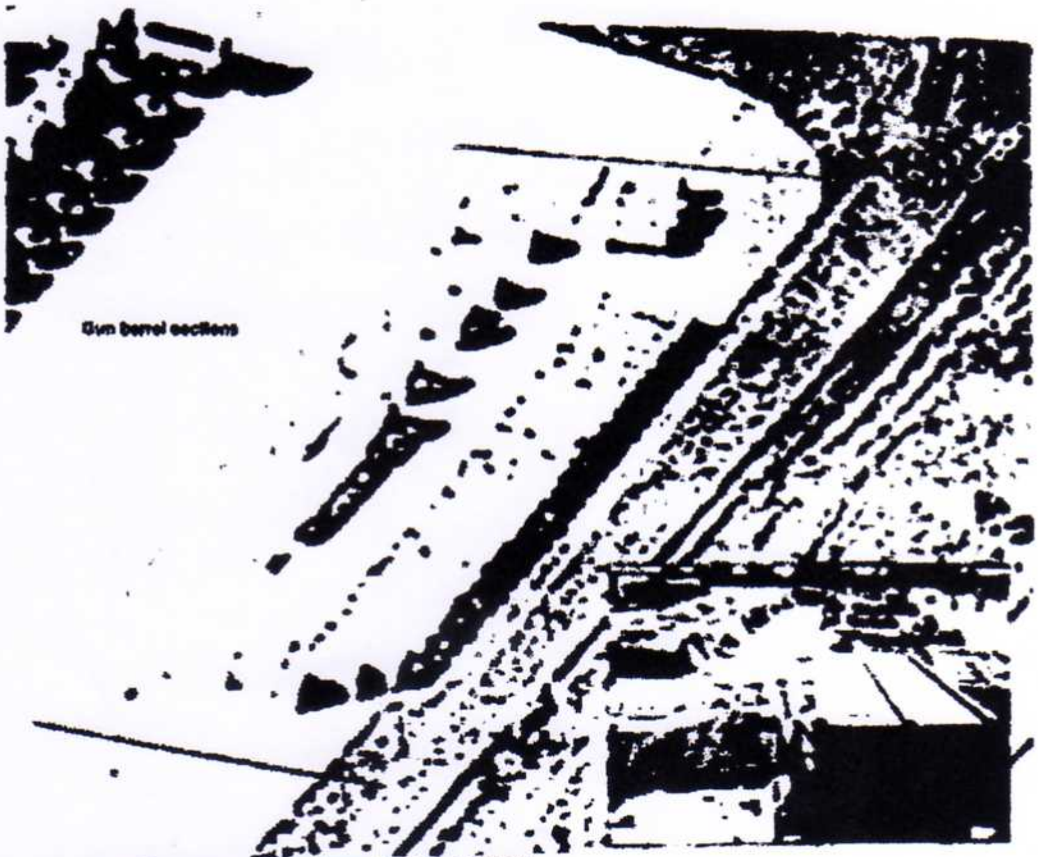

Figure 14. Satellite imagery of Iskandiana, Iraq, shows what we believe to be the large barrel sections that were to make up the full barrel for the 1,000-mm supergun. (S NF NC OC)

The final testing of the S-350 L150, with subcaliber projectiles fired downrange for the first time, was to occur at the end of March 1990 (see figure 16). We believe that this test program was probably never completed. These tests were designed to more accurately replicate how the larger supergun would be used. The gun was mounted against the side of a mountain and would fire both subcaliber and rocket projectiles as they became available. Data from these tests were to be used to calibrate the exterior ballistics calculations made for the subcaliber projectiles fired from the 350-mm gun—specifically to determine whether their expected range would be achieved and if so, be a military threat to Israel. (S NF NC OC)

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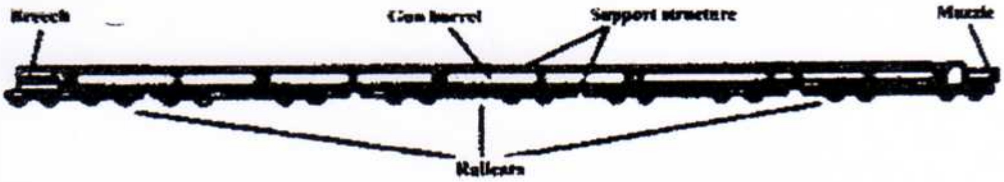
Figure 15
S-350 L150 Test Gun Mounted on Railcars



The S-350 L150 scaled version of the 1,000-mm supergun, with its 52.5-meter-long barrel, was initially mounted horizontally onto railcars. This phase of the test program was designed to test the overall design and construction concept of the gun.

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A Future for Project Babylon?

We assess that the Iraqi Supergun will not be completed, especially since UN Inspection teams are rendering the gun barrels inoperable. Further, we believe that Iraq will not continue the development of any of the other 350-mm guns of Project Babylon. Unlike Bull's GC-45 artillery guns, the guns of Project Babylon were not "whole systems" that could be purchased by the Iraqis. (S NC)

We believe that Iraqi expectations of the success and progress of Project Babylon were inflated, on the basis

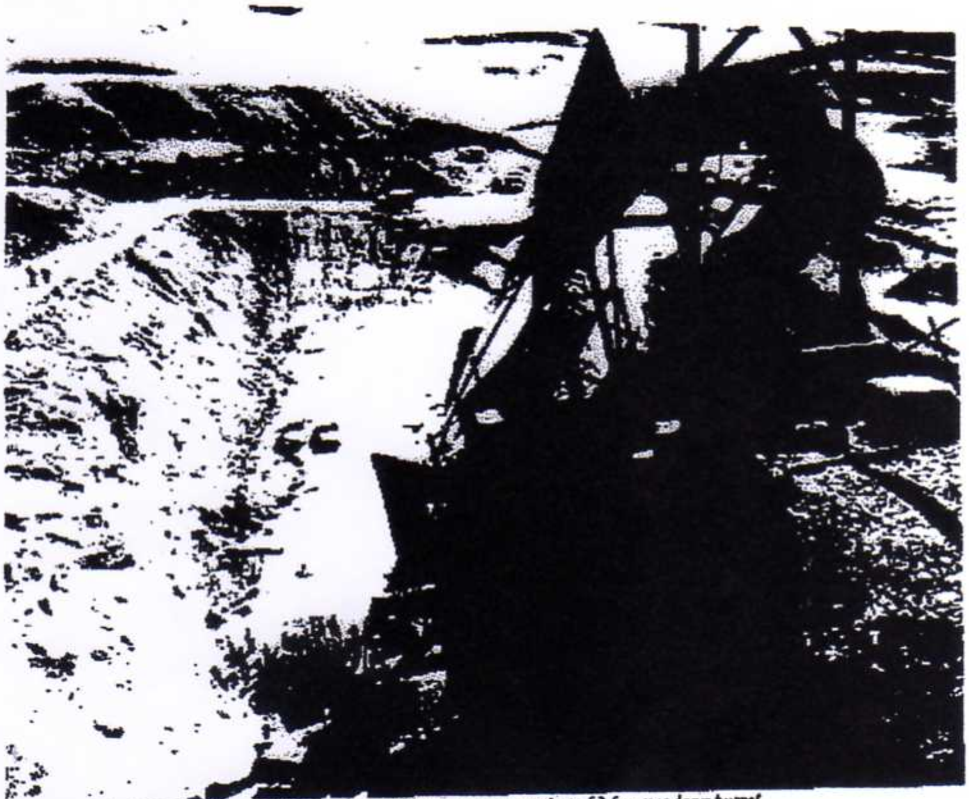

Figure 16. The S-350 L150 scaled version of the S-1000 supergun with its 52.5-meter-long barrel

of promises from the SRC. We are uncertain why the SRC felt the need to conduct such a formidable weapons development program at such an accelerated pace. Even though Project Babylon's foundation was the proven technology of the HARP program, significant development time, representing at least a two- to three-year program, was required according to SRC documents. This development program depended on much work being performed in parallel with out-of-country assistance. (S NF)

Notwithstanding the efficiencies of using a gun as a first stage for rocket projectiles and the "reusable" nature of a gun, we believe that the lack of mobility inherent in such a large system would make it vulnerable and place serious restrictions on its use as a weapon in a future conflict. (S NF)

Directorate of Intelligence

Secret
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ORCON

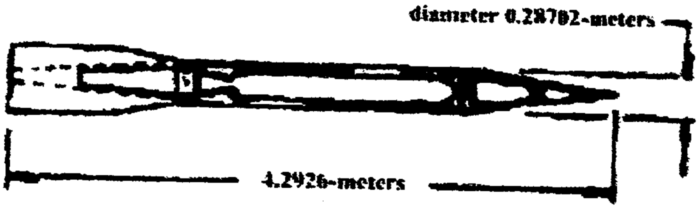
Project Babylon: The Iraqi Supergun (U)

Interior Ballistics

Reverse Blank

Secret
SW 91-10076X
November 1991

CIA DIRECTORATE OF INTELLIGENCE HIGH-ALTITUDE ROCKET TECHNICAL DRAWING ARCHIVE



Martlet 2G-1

Weight: 130.181 kg (first stage)
Fuel: 108.862 kg
Weight: 41.2769 kg (second stage)
Fuel: 34.0194 kg
Total Weight: 498.951 kg

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Interior Ballistics Martlet 2G-1/1

Gross Mass:	500 kilograms
Payload	2 kilograms
Height	4.29 meters
Diameter	0.30 meters
Zenith	185 kilometers

Interior Ballistics Martlet 2G-1/2

Gross Mass:	130 kilograms
Payload	21 kilograms
Height	3.21 meters
Diameter	0.29 meters
Span	0.45 meters

The 2G-1 was a 7-inch diameter, two-stage solid propellant gun-launched rocket that was sabot-launched from the HARP 16-inch gun. Its total payload in orbit was just 2 kg. It was fired from the 16-inch gun in Highwater, Quebec. This rocket represented a catalyst towards Gerald Bull's real ambition, a gun-launched rocket that could reach outer space. In the final year of the HARP program, when Bull recognized he would not receive further funding, and that his goals for the Martlet 4 program were not to be realized, he diverted all his endeavors to developing the Martlet 2G-1. Bull believed that if a satellite—no matter how small—could be successfully gun-launched, it would be possible to encourage further funding, which would permit the orbital goals of the HARP program to be realized. Time was against Bull and the HARP program was closed down on June 30 1967, a few months before an orbital 2G-1 could be launched. (S NF NC)

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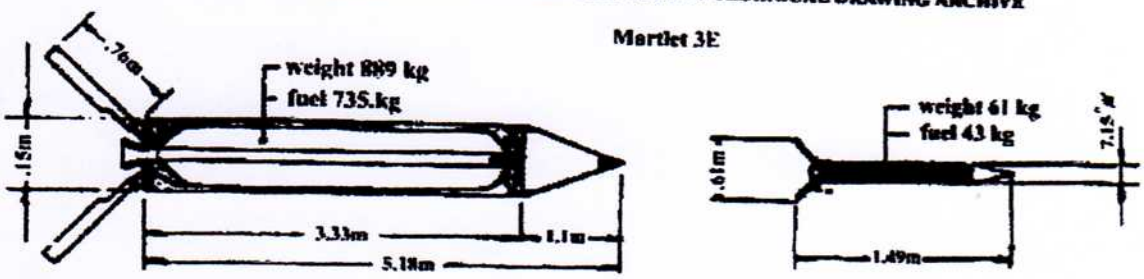
Martlet 3E



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Interior Ballistics Martlet 3E	
Gross Mass:	155 kilograms
Payload	20 kilograms
Height	2.15 meters
Diameter	0.18 meters
Zenith	250 kilometers

The Martlet 3E gun-launched rocket was fired from one of the HARP guns. It was designed to take advantage of the portability of the HARP 7-inch guns. Unlike the big fixed 16-inch guns the 7-inch HARP guns. were portable and could be relocated to conduct launches from a wide variety of sites. (S NF NC)

The Martlet 3E was a full-bore, rocket-assisted, fiberglass airframe rocket. It used six flip-out fins for stability, a straight tapered nose cone, and the hydrostatic containment technique to support the rocket grain during launch. It was initially designed to be launched at a velocity of 1200 m/sec from the HARP 7-inch guns with a 12 second ignition delay and a seven second rocket motor burn time. The specific impulse of the rocket motor was 280 sec./vacuum. Theoretical performance of the 3E would have allowed a 20 kg payload to be lofted to an altitude of some 250 km—well in excess of the Martlet 2 rockets performance envelope. Higher launch velocities would have allowed heavier payloads or higher altitudes to be realized. (S NF NC)

Most of the development flights of the Martlet 3E were conducted using surplus 155-mm smoothbore guns in place of the 7-inch guns. Once the primary design problems of the 3E were worked out it was intended to scale the design up from the 6.25-inch to 7.17-inch. The final high altitude vertical flight-testing was to be conducted with the 7-inch gun systems. (S NF NC)

With the launch costs of the Martlet 3E in the same range as a Martlet 2 rockets it was intended that once the 3E became operational it would replace the Martlet 2 as the primary atmospheric sounding rocket for the HARP Program. The use of the 3E over the Martlet 2 would allow portable soundings to be conducted all over the world. This would also free up the 16-inch gun for the future development and operation of a gun-launched satellite rocket. (S NF NC)

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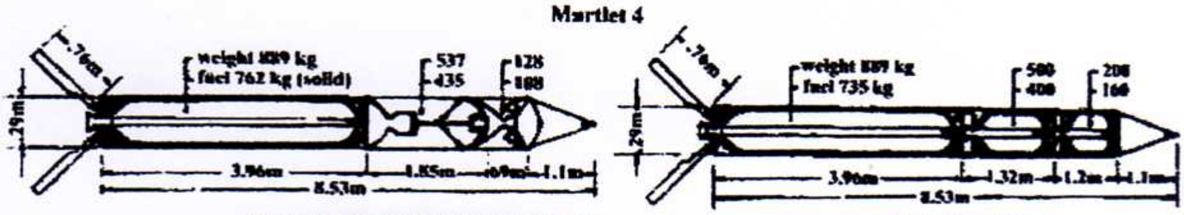
Martlet 4



Martlet 4 liquid fuel (upper stages) **Martlet 4 solid fuel**

Secret NOFORN NOCONTRACT 112925 11-91

Interior Ballistics Martlet 4

Gross mass:	1,300 kilograms
Payload:	23 kilograms
Height:	8.54 meters
Diameter:	0.42 meters
Thrust:	47.40 Knudsen number
Zenith:	425 kilometers

The intent of the Martlet 4 full-bore, gun-launched rocket, fired from the 16-inch HARP gun, was to launch payloads into low Earth orbit. Weighing in at over a ton the Martlet 4 was considerably heavier then any of the other 16-inch Martlet rockets although it was in the same weight range as a standard 16-inch military missile. The very heavy shot weight of the Martlet 4 required that an entirely new propellant charge be developed specifically for the Martlet 4 and research was performed to develop a propellant charge that would provide the highest possible launch velocity from the 16-inch gun. Throughout the HARP project there was a continuous effort to develop improved propellant charges for all of the HARP guns in order to increase the launch velocities of the various Martlet rockets. (S NF NC)

The Multi-Point Spaced Ignition Charge for the Martlet 2 rockets solved many of the problems encountered earlier in the program with erratic burn rates and was the basis for the Martlet 4 propellant charge. The Multi-Point Spaced Ignition Charge for the Martlet 2 series consisted of about 900 pounds of M8M propellant divided into eight propellant bags. These bags were loaded into the gun in four sets of two bags with spacers to keep the bag pairs separated by about 18-inches. With a conventional charge the propellant was ignited at the breach end and the flame front progresses from one bag to the next. With the Multi-Point Spaced Ignition Charge each bag was ignited simultaneously which produced a very even ignition and helped to stabilize the pressure curve. The standard Martlet 2 charge was not suitable for the much heavier Martlet 4. The primary reason for this was that the propellant grain size and the burn rate of the propellant were matched by the lighter shot mass of the Martlet 2. The lighter Martlet 2 accelerated down the bore much quicker then the heavier Martlet 4. The high burn rate of the standard Martlet 2 propellant charge would have generated too much propellant gas too soon, resulting in an overpressure and the destruction of the gun. (S NF NC)